Software Requirements Management

Space Shuttle Lessons Learned #3377

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Application Software

- Launch Processing System (LPS) Application Software is used in the Launch Control Center Firing Room to perform Vehicle & Ground Support Equipment (GSE) testing and launch of the Space Shuttle.

- GOAL: Ground Operation Aerospace Language

  Developed (1977) as a very high order, English-like language

- Approximately 2500 programs, 2 Million lines of code

  (Firing Room/Launch Configuration)
- > 1000 GOAL Displays, > 760 PCGOAL Displays

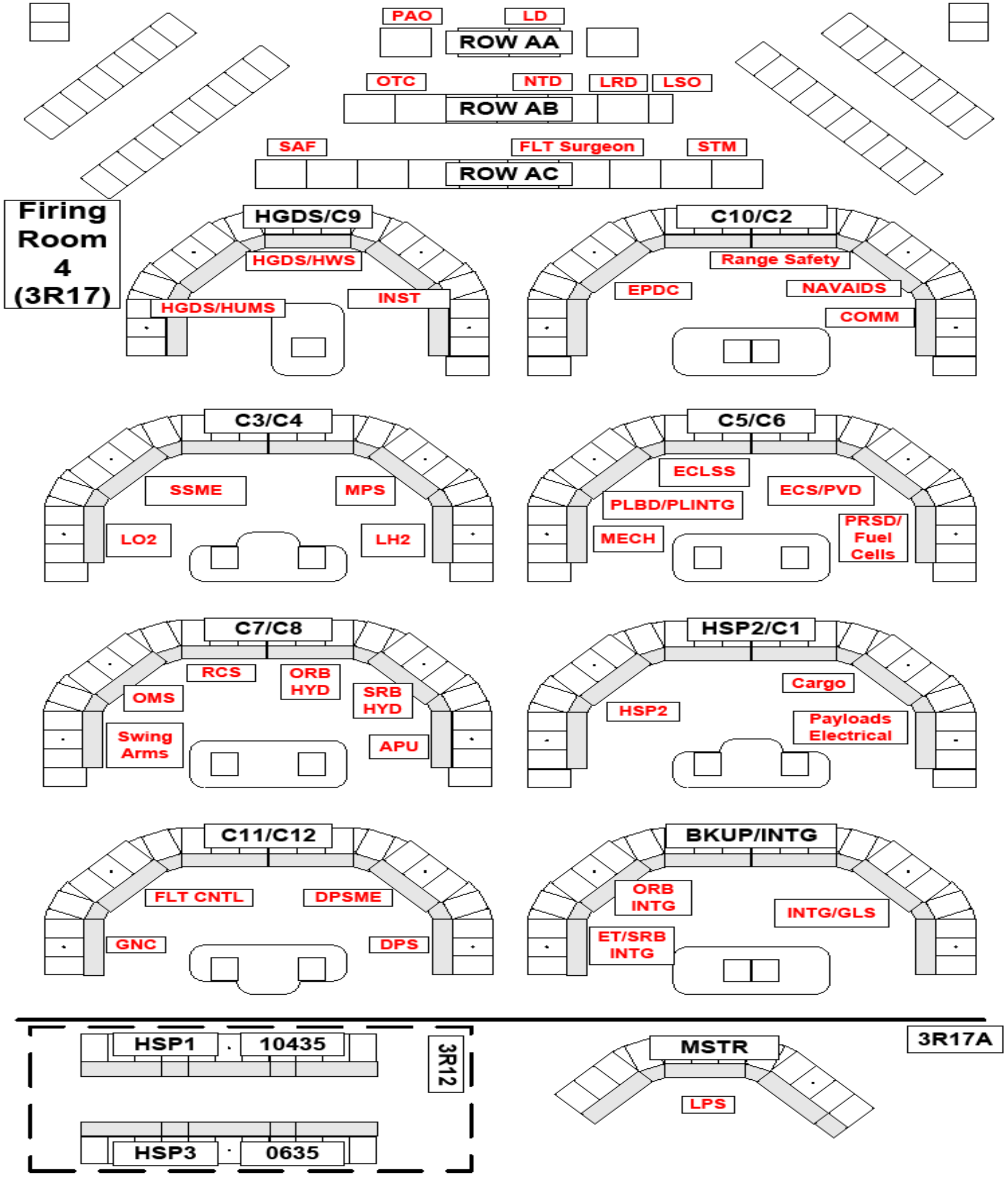
- > 50,000 Command and Measurement parameters:

  30,000 Vehicle / 20,000 GSE

  (Function Designators/FDs, Measurement & Stimuli IDs/MSIDs)

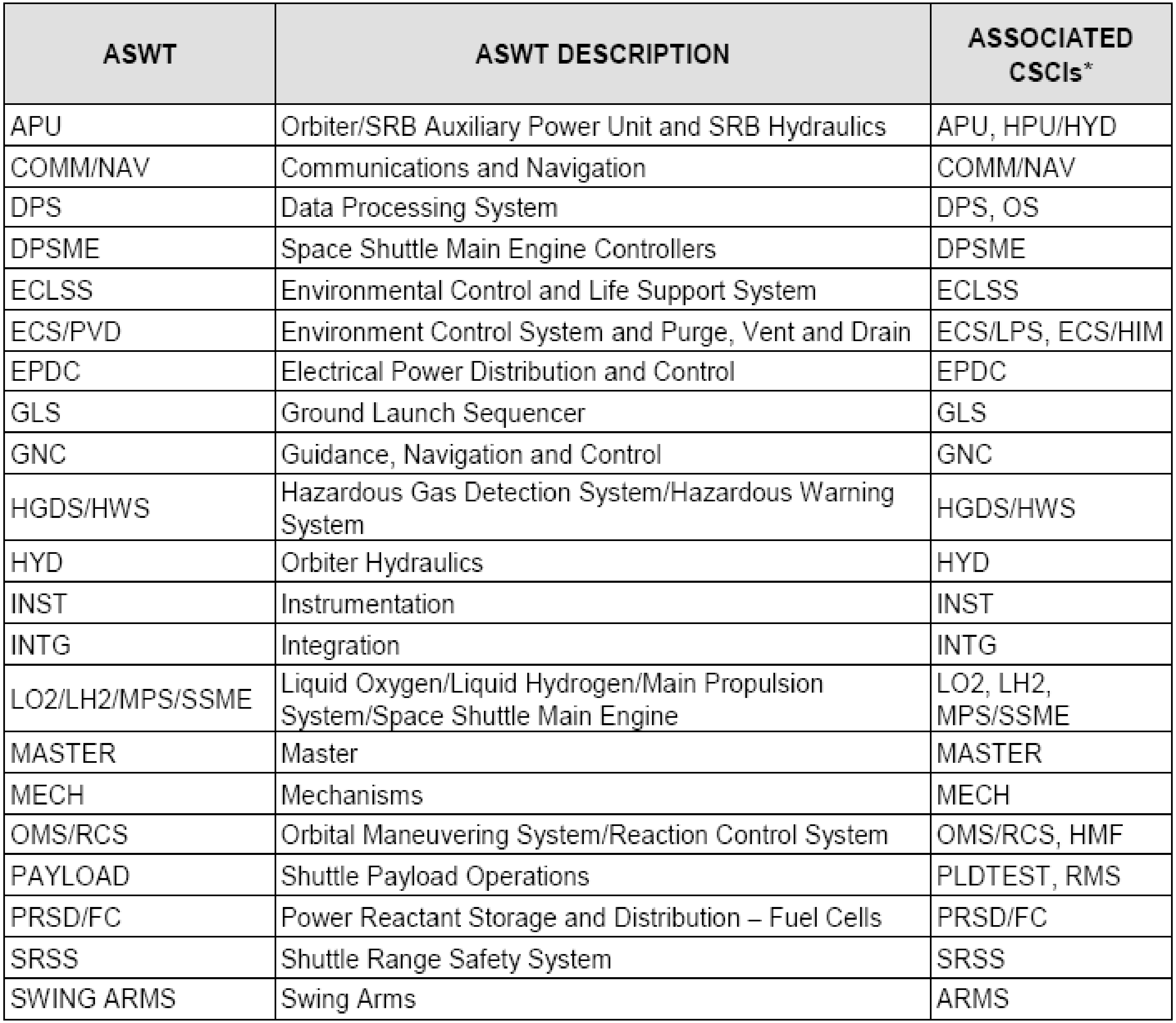
KSC ENGINEERING

Firing Room 4 Layout



CHARTERED Application Software Working Teams

The following ASWTs have been officially chartered by the LPS Application Software TRP.



ASWT	ASWT DESCRIPTION	ASSOCIATED CSCIs*
APU	Orbiter/SRB Auxiliary Power Unit and SRB Hydraulics	APU, HPU/HYD
COMM/NAV	Communications and Navigation	COMM/NAV
DPS	Data Processing System	DPS, OS
DPSME	Space Shuttle Main Engine Controllers	DPSME
ECLSS	Environmental Control and Life Support System	ECLSS
ECS/PVD	Environment Control System and Purge, Vent and Drain	ECS/LPS, ECS/HIM
EPDC	Electrical Power Distribution and Control	EPDC
GLS	Ground Launch Sequencer	GLS
GNC	Guidance, Navigation and Control	GNC
HGDS/HWS	Hazardous Gas Detection System/Hazardous Warning System	HGDS/HWS
HYD	Orbiter Hydraulics	HYD
INST	Instrumentation	INST
INTG	Integration	INTG
LO2/LH2/MPS/SSME	Liquid Oxygen/Liquid Hydrogen/Main Propulsion System/Space Shuttle Main Engine	LO2, LH2, MPS/SSME
MASTER	Master	MASTER
MECH	Mechanisms	MECH
OMS/RCS	Orbital Maneuvering System/Reaction Control System	OMS/RCS, HMF
PAYLOAD	Shuttle Payload Operations	PLDTEST, RMS
PRSD/FC	Power Reactant Storage and Distribution – Fuel Cells	PRSD/FC
SRSS	Shuttle Range Safety System	SRSS
SWING ARMS	Swing Arms	ARMS

Application Software Working Teams* (ASWT)

KSCL-1160-0369 ASWT CHARTER

The ASWT is the primary point of contact and responsible for all aspects of Checkout, Control and Monitor Subsystem (**CCMS**) Application Software development.

Each ASWT is responsible for the development and maintenance of the Application Software required to support checkout and launch activities for the associated **vehicle/ground support equipment (GSE)** systems. Each ASWT can be responsible for **one or more Computer Software Configuration Items (CSCI)**, which equates to an Application Software set.

* **21 ASWTs**

ASWT Member Responsibilities

- Shuttle/System Engineering
  - **Determination of *requirements* needed for checkout and launch**
  - **Allocation of *requirements* to hardware and software implementations**
  - **Development of software *requirements***
  - **Technical support to software engineering**
  - **Validation of application software**
- Software Engineering
  - **Assessment of *requirements***
  - **Code development and verification**
  - **Maintenance of design documentation**
  - **Assist Shuttle/System engineering**

These **(ASWT)** functions include:

A. **Requirements Identification**

The team is responsible for identifying the **software requirements** necessary to **implement all program directed changes**, **all** Operational Maintenance Requirements Specification (**OMRS**) and Launch Commit Criteria (**LCC**) **requirements** and **all operational enhancement changes** necessary to improve the safety and efficiency of checkout and launch activities. The specifics of how to perform this identification are defined in USA004715 and USA004732.

B. **Application Software Development Planning**

The team shall be responsible for the detailed planning of all software development activities related to the system. This includes **maintaining a prioritized schedule of all mandatory and non-mandatory requirements** that must be implemented. These plans and schedules shall be maintained by the team for tracking, statusing and presentation to management upon request.

C. **Application Software Development**

The team is responsible for development, testing and verification of all Application Software for the associated vehicle/GSE system. The specifics of the development activities are defined in USA004715 and USA004732.

D. **Action Item Tracking**

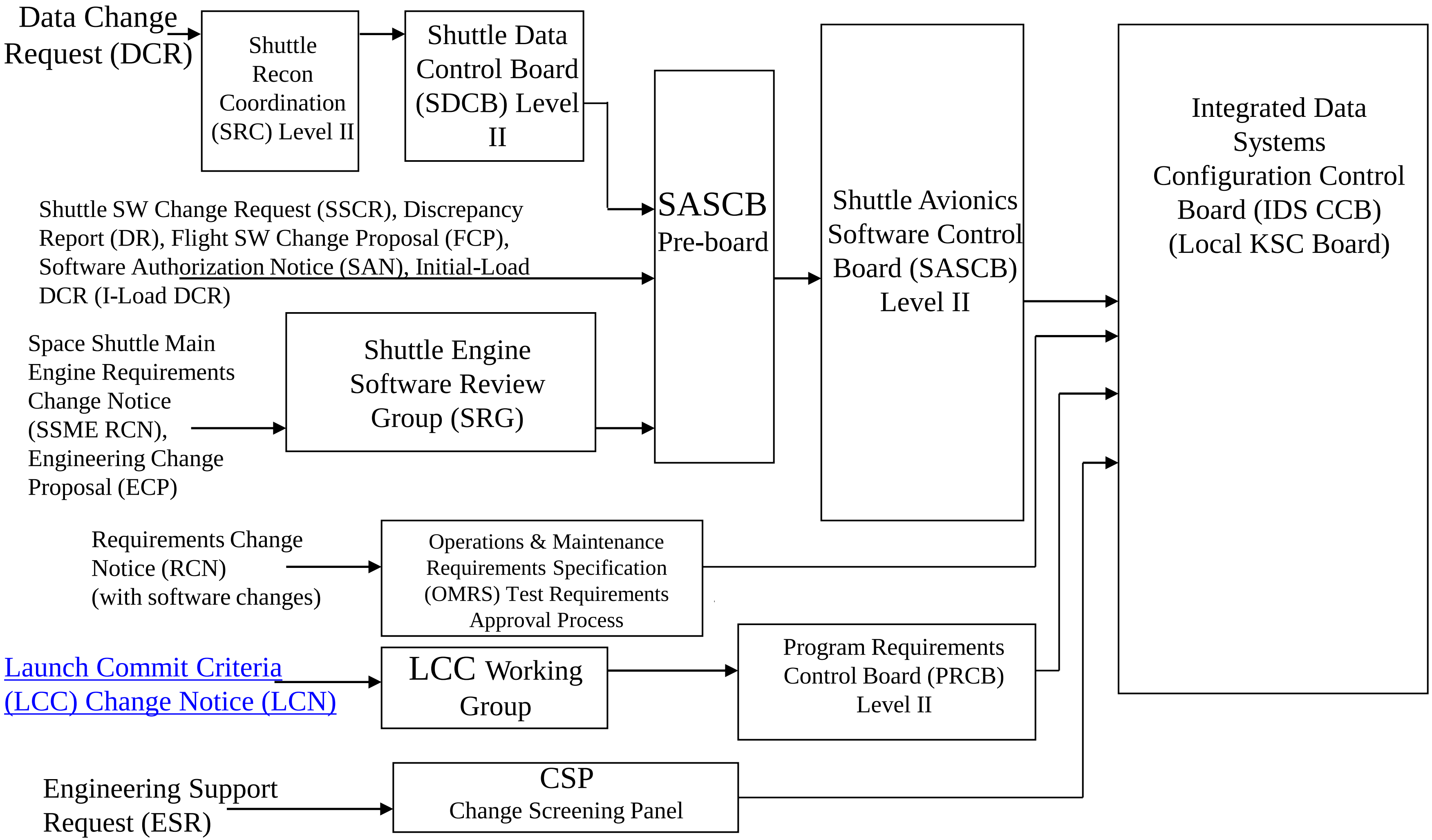
The team is responsible for tracking and responding to all external action items assigned (e.g., by TRP, CCB) and all internal action items (e.g., Shuttle Configuration Management System (SCMS) or Open Item Status Report (OISR) items within the allotted time frames. These action items shall be tracked in the ASWT minutes, with responsibility for the action assigned to specific individuals and projected completion dates defined. The team is responsible for implementing any tasks resulting from the assigned action items.

E. **Issue Resolution**

The team is responsible for resolving all issues associated with the Application Software of all associated **CSCIs**. If an issue cannot be resolved at the ASWT level, the ASWT Lead and CSCI Lead may elevate the problem to their First Line Managers and/or the Application Software Technical Review Panel (TRP) for assistance in reaching resolution.

Refer to IDS-SEPG-058, LPS Defined Software Process, for the issue escalation process to use in these instances.

Requirements Processing and Control Boards



Data Change Request (DCR)

Shuttle Recon Coordination (SRC) Level II

Shuttle Data Control Board (SDCB) Level II

Shuttle SW Change Request (SSCR), Discrepancy Report (DR), Flight SW Change Proposal (FCP), Software Authorization Notice (SAN), Initial-Load DCR (I-Load DCR)

SASCB Pre-board

Shuttle Avionics Software Control Board (SASCB) Level II

Integrated Data Systems Configuration Control Board (IDS CCB) (Local KSC Board)

Space Shuttle Main Engine Requirements Change Notice (SSME RCN), Engineering Change Proposal (ECP)

Shuttle Engine Software Review Group (SRG)

Requirements Change Notice (RCN) (with software changes)

Operations & Maintenance Requirements Specification (OMRS) Test Requirements Approval Process

Launch Commit Criteria (LCC) Change Notice (LCN)

LCC Working Group

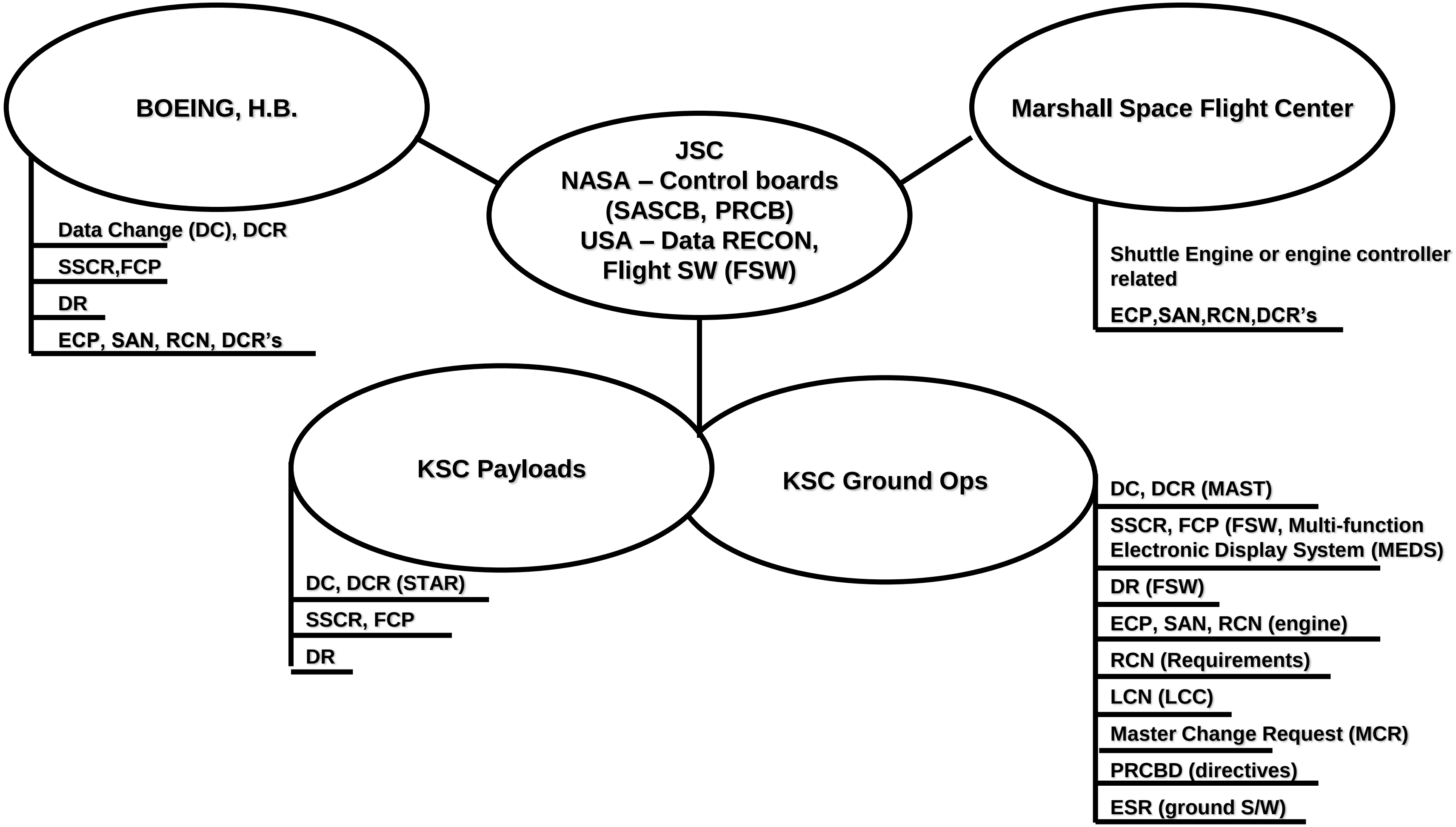
Program Requirements Control Board (PRCB) Level II

Engineering Support Request (ESR)

CSP

Change Screening Panel

Requirements Processing and Control Boards



JSC
NASA – Control boards
(SASCB, PRCB)
USA – Data RECON,
Flight SW (FSW)

BOEING, H.B.

- Data Change (DC), DCR
- SSCR,FCP
- DR
- ECP, SAN, RCN, DCR's

Marshall Space Flight Center

- Shuttle Engine or engine controller related
- ECP,SAN,RCN,DCR's

KSC Payloads

- DC, DCR (STAR)
- SSCR, FCP
- DR

KSC Ground Ops

- DC, DCR (MAST)
- SSCR, FCP (FSW, Multi-function Electronic Display System (MEDS)
- DR (FSW)
- ECP, SAN, RCN (engine)
- RCN (Requirements)
- LCN (LCC)
- Master Change Request (MCR)
- PRCBD (directives)
- ESR (ground S/W)

Software Engineering Life Cycle

PHASES:

1. Project/Task Initiation
2. Requirements Analysis and Definition
3. Software Implementation
4. Acceptance Test
5. Release and Delivery

A succession of phases in a software development life cycle are formalized in a software process model

Software Engineering “Model”

Capability Maturity Model Integration ® (CMMI) developed by Software Engineering Institute (SEI), Carnegie Mellon University

CMMI provides guidance for improving an organization’s processes and the ability to manage the development, acquisition, and maintenance of products or services

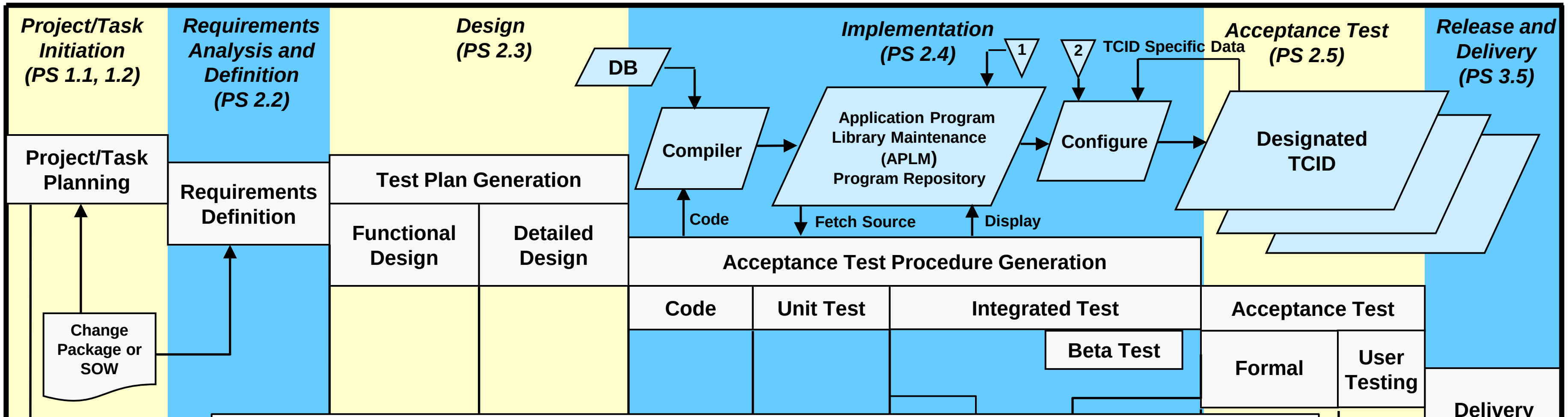
United Space Alliance (USA) Integrated Data Systems

Space Flight Operations Contract (SFOC):

- CMM Level 3, Dec. 2004

(Advent of LPS Software **Requirements** “**Tagging**” and “**Tracking**”)

- CMMI Level 3, Mar. 2006



Project/Task Initiation (PS 1.1, 1.2)

Requirements Analysis and Definition (PS 2.2)

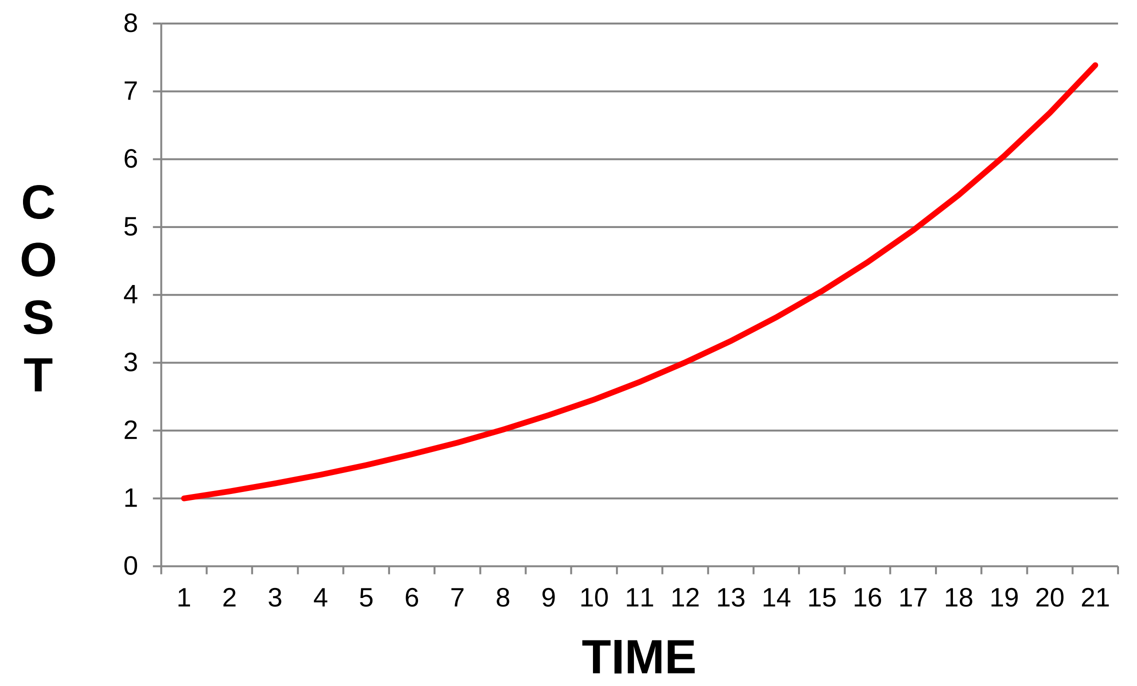
Design (PS 2.3)

Implementation (PS 2.4)

Acceptance Test (PS 2.5)

Release and Delivery (PS 3.5)

RESULT OF ADDITIONAL/DELAY OF REQUIREMENTS



Activity

Product

Milestone

ument

ts Specification

s Review

CI – Configuration Inspection

RTVM – Requirements Traceability Verification Matrix

TRR – Test Readiness Review (occurs after VRR but prior to the start of Acceptance Test)

- Backup

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- **Abstract:**

  The ability to manage and trace software requirements is critical to achieve success in any software project and to produce software products in a cost-effective and timely fashion. Conversely, incomplete, incorrect, or changing software requirements result in cost and schedule impacts that increase the later they occur (or are discovered) in the software life cycle. Current software technology, processes, and tools provide innovative, automated methods to facilitate optimum management of software requirements. Additionally, a collaborative relationship between the customer, or user, of the software and the developer of the software is essential to the success of the software project. That is, the user/customer requirements must be accurately communicated and understood to be correctly implemented in the software in order to meet end-users needs.

- **Description of Driving Event:**

  The legacy (manual) methods for managing the implementation of software requirements for the Space Shuttle Program have had a major impact on cost and schedule over the entire software development life cycle.

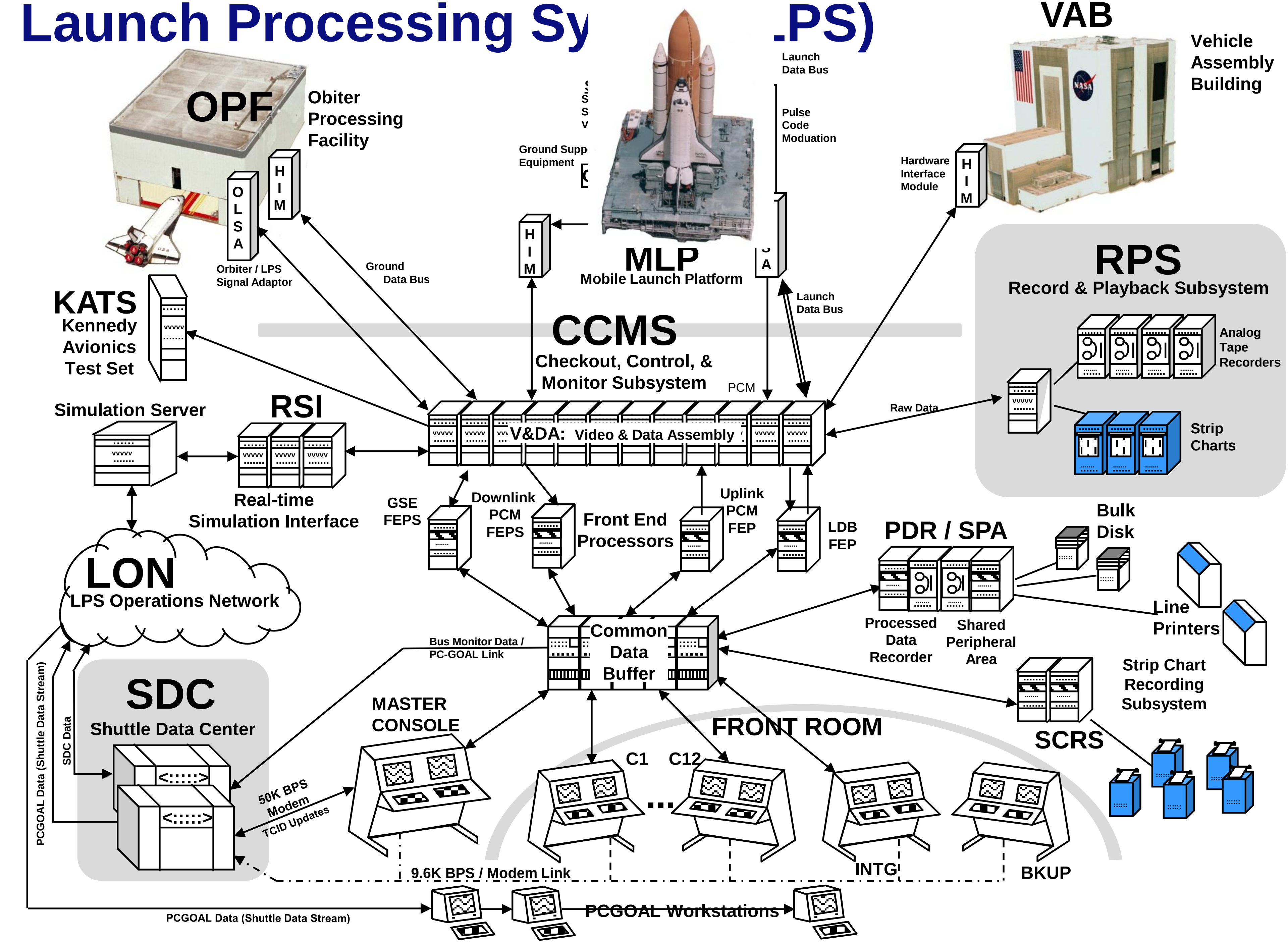
- **Lesson(s) Learned:**

  Manual methods for management of software requirements are ineffective and inefficient, contributing to excessive costs as well as schedule delays. Aspects of the management of software requirements include the elicitation/specification, analysis, development, tracking, and changing of software requirements used during the implementation and sustaining phases of the software life cycle. Management and traceability of software requirements are critical to the success of producing reliable, high-quality, and safe software products that meet end-users requirements and needs in a cost-effective and timely fashion. Cost and schedule impacts that result from incomplete, incorrect, or changing software requirements increase the later they occur in the software life cycle. Current software technology, processes, and tools provide innovative automated methods to facilitate optimum management of software requirements (e.g., IBM Rational DOORS, IBM Rational RequisitePro, Cradle requirements management software). Additionally, a collaborative relationship between the customer using the software and the developer providing the software is paramount to the success of the software project. More specifically, the users/customers must effectively define and accurately communicate their requirements to the developer. For example, the user's defined requirements should be clearly stated and unambiguous, concise, complete, autonomous, able to be implemented, and testable.

- **Recommendation(s):**

  Adopt and use current, state-of-the-art software processes and tools to manage requirements for software development. Value and foster the collaborative relationship between the customer who uses the software and the developer providing the software to ensure the success of the software project.

Launch Processing Sy .PS)



VAB
Vehicle Assembly Building
OPF
Obiter Processing Facility
H I M
O L S A
Orbiter / LPS Signal Adaptor
Ground Data Bus
S S S V
Ground Supp
Equipment
Launch Data Bus
Pulse Code Moduation
Hardware Interface Module
MLP
Mobile Launch Platform
A
Launch Data Bus
RPS
Record & Playback Subsystem
Analog Tape Recorders
Strip Charts
Raw Data
KATS
Kennedy Avionics Test Set
CCMS
Checkout, Control, & Monitor Subsystem
PCM
V&DA: Video & Data Assembly
vvvvv
Simulation Server
RSI
Real-time Simulation Interface
GSE FEPS
Downlink PCM FEPS
Front End Processors
Uplink PCM FEP
LDB FEP
PDR / SPA
Processed Data Recorder
Shared Peripheral Area
Bulk Disk
Line Printers
LON
LPS Operations Network
Common Data Buffer
Bus Monitor Data / PC-GOAL Link
Strip Chart Recording Subsystem
SCRS
SDC
Shuttle Data Center
SDC Data
PCGOAL Data (Shuttle Data Stream)
50K BPS Modem
TCID Updates
MASTER CONSOLE
FRONT ROOM
C1
C12
...
INTG
BKUP
9.6K BPS / Modem Link
PCGOAL Workstations
PCGOAL Data (Shuttle Data Stream)